Instruction Manual
AVTM 21-40Ja

For the

2.5/5kV Megohmmeter Test Set

Catalog No. 210400

AVO®

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Instruction Manual for

2.5/5 kV Megohmmeter Test Set

Biddle Catalog No. 210400

High-Voltage Equipment

Please Read Carefully Before Operating

Safety is the responsibility of the user

Aparato de Alto Voltaje

Sirvanse Leer Este Libro Con Cuidado
Antes de Operarlo

La seguridad es la responsabilidad del operador

BIDDLE INSTRUMENTS
Blue Bell, PA. 19422

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SECTION A

INTRODUCTION

This Instruction Manual is intended as a guide to the operation and maintenance of the portable 2.5/5kV Megohmmeter Test Set, Biddle Catalog No. 210400. References in this manual to optional functions and equipment may be disregarded when such information does not apply to the test set in use. The options included in the set for which this manual is supplied are indicated in nameplate data.

The instructions and suggestions provided in this manual anticipate the normal use of the Megohmmeter Test Set for testing electrical insulation systems on such equipment as motors, generators, bushings, and cables. These tests, which are based on measurement of the applied dc voltage, the equivalent resistance, and the manner in which resistance varies with time, provide data that indicate the condition of the insulation system of the unit being tested. When these data are recorded on graph paper such as Biddle kilovolt-megohm paper (Catalog No. 220000), the shape of the curve made by connecting the plotted points will aid in evaluating the condition of the insulation system. Information on the interpretation of observed data and guides for testing are given in Section J.

The Biddle 2.5/5.0 kV Megohmmeter Test Set, Catalog No. 210400

SECTION B

SAFETY PRECAUTIONS

SAFETY IS THE RESPONSIBILITY OF THE USER.

LA SEGURIDAD ES LA RESPONSABILIDAD DEL OPERADOR.

The test set and the equipment to which it is connected are a source of high-voltage electrical energy, and all persons performing or assisting in the tests must use all practical safety precautions to prevent contact with energized parts of the test equipment and associated circuits. Persons actually engaged in the test must stand clear of all parts of the complete high-voltage circuit unless the test set is deenergized and all parts of the test circuit are grounded. Persons not directly associated with the work must be kept away from test activities by suitable barriers, barricades or warnings.

Since the energized test setup may induce a static voltage charge on nearby insulated objects, including people, all insulated objects must be grounded or kept at least one foot from the energized structure.

At the completion of a test, after the power source has been shut down and the test set kilovoltmeter reads zero, all energized parts of the test setup must be short-circuited by means of a safety ground (hot stick). Ground bonds should then be applied to the equipment that was tested and left in place until access to the equipment is again required.

If the test set is operated in accordance with the safety precautions noted above and in Section G, and if all grounds are correctly made, rubber gloves are not necessary. As a routine safety procedure, however, some users require that rubber gloves be worn, not only when making connections to the high-voltage terminals, but also when manipulating controls. Biddle Instruments considers this an excellent safety practice.

NOTE: High voltage discharges and other sources of strong electric or magnetic fields may interfere with the proper functioning of heartpacemakers. Personnel using heart pacemakers should obtain expert advice on the possible risks before operating this equipment or being close to the equipment during operation.

WARNING

NEVER CONNECT THE TEST SET TO ENERGIZED EQUIPMENT OR USE THE TEST SET IN AN EXPLOSIVE ATMOSPHERE.

SECTION C

RECEIVING INSTRUCTIONS

When your Biddle instrument arrives, check the equipment received against the packing list to ensure that all materials are present. Notify Biddle Instruments, Blue Bell, Pa., of any shortage of materials.

Examine the instrument for damage received in transit. If any damage is discovered, file a claim with the carrier at once and notify Biddle Instruments, or its nearest authorized sales representative, giving a detailed description of the damage observed.

This instrument has been thoroughly tested and inspected to meet rigid inspection specifications before being shipped. It is ready for use when set up as indicated in Section G.

SECTION D

SPECIFICATIONS

POWER SUPPLY Cat. 210400

Voltage (rms): 105-130 volts

Recommended Source: NEC 15-Ampere, 120 volt single-phase branch circuit.

Current (rms): 1.1 Amperes, continuous.

Frequency: 60 Hz, Full Rating
50 Hz, Reduced Rating

Rated Performance: Based on 120-volt, 60 Hz line.

OPTIONAL POWER SUPPLY Cat. 210400-47

Voltage (rms): Specify nominal voltage on order.

NOMINAL	RANGE	MAXIMUM CURRENT
210 V	208 to 225 V	0.6 A
230 V	225 to 240 V	0.63A
250 V	240 to 265 V	0.65A

Recommended Source: 10-Ampere, nominal voltage, single-phase branch circuit.

Frequency: 60 Hz full rating; 50 Hz reduced rating.

Rated Performance: Based on 230-volt, 60 Hz line.

OUTPUT TEST VOLTAGE: 0-5kV DC, negative with respect to ground.

OUTPUT CURRENT: 5mA, continuous (4.2mA, 50 Hz).

Short Circuit: 12mA Maximum.

Ripple Voltage (rms): 1%, full load resistive burden.

Regulation: 20%, no load to 1 megohm load.

METERING

Kilovoltmeter: 4½ inch taut band; 3 scales, 0-2.5, 0-5 kV and 0-1 reference.

Accuracy: ±2% F.S.

Megohm Meter: 4½ inch taut band, 2 scales, 0.5 to 50.0 and 1.0 to 100.0 megohms

Accuracy: ±1/32 inch (0.08 cm) at any marking

Ranges: 8 ranges, 4 per scale, as in Table.

VOLTMETER RANGE SETTING	VOLTAGE	MEGOHM METER SPAN, MEGOHMS			
		RANGE SW AT X1	RANGE SW AT X10	RANGE SW AT X100	RANGE SW AT X1K
5.0	5 kV	1-100	10-1000	100-10,000	1000 to 100,000
2.5	2.5 kV	0.5-50	5-500	50-5,000	500 to 50,000
Either	Any	SEE SECTION H			

CONTROLS

Test set ON-OFF switch (Circuit breaker)

Voltage Control with zero-start interlock.

Voltmeter range switch (2.5 kV and 5.0 kV).

Megohm Meter 4-position range switch X1, X10, X100 x 1K

Meter damping switch (IN-OUT)

Power ON lamp.

PHYSICAL

Case: High impact laminated construction.

Size: 13½ x 9 3/8 x 10 inches (34.3 x 24.8 x 25.9 cm)

Weight: 20.5 lbs. (9.3 kg.)

Input Cable: attached 3-wire with plug, 5 ft. (1.5 meters)

Output Cable: attached coaxial with guard and high voltage terminals, 15 ft. (4.6 meters).

Ground Cable: Separate, 10 ft. (3.3 meters).

Cable Compartment: Storage of cables and instruction manual.

Instruction Card: Permanently attached in case cover.

ENVIRONMENT

Temperature: 122°F (50°C) maximum operating.

Altitude: 10,000 ft. (3,048 meters) maximum operating.

Relative Humidity: non-condensing conditions.

Vibration: will withstand vibration normally encountered during field use and transportation.

PROTECTIVE DEVICES

Circuit Breaker: Protects against any overload condition.

Zero Start: Safety feature; Requires output voltage be zero to start test.

Voltmeter and Megohm Meter: Protected against overload and transients by special circuits.

SECTION E

DESCRIPTION

General

The portable Megohmmeter Test Set measures the electrical quantities of applied voltage and resistance of the apparatus to which it is connected. Designed for field or shop use, the complete test set (including all leads) is housed in a rugged structural foam, polycarbonate case that includes a sturdy protective lid and carrying strap. For safety in operation, the control panel of the test set is of grounded metal.

Electrical Operation

The electrical operation of the test set is described below and illustrated in the schematic diagram provided in Figure 1.

Transformer T102, rectifiers CR103 and CR104, and capacitors C101 and C102 form a full-wave, voltage doubling rectifier circuit. This circuit is provided with safety bleeder resistors R101 and R102 and protected by the output limiting resistor R107. The output cable W101 is permanently connected to the negative terminal of the rectifier system. The positive terminal of the rectifier system is considered the guard terminal; it is connected to the shield of the output cable but is isolated from ground. (See Section G). The GUARD is available at the end of the output cable as a terminal.

Output voltage is measured by the two-range kilovoltmeter, consisting of multiplier resistor R103 and meter M101. Voltmeter range is selected by means of a front panel switch S101 and resistors R104, R105 and R106. The voltmeter circuit is protected from surges by capacitor C103.

Resistance to ground in the apparatus under test is measured by the four-range two-scale microammeter calibrated in megohms M102. Ranges are selected by a front panel switch that is part of the printed circuit card E102. This card contains the range selector resistors R1, R2, R3, R4, R5, R6 and R7. Also on E102 are the meter circuit protection elements capacitor C1 and Zener diode CR1. The current meter has a sensitivity of 100 μA. To obtain the required 5 μA sensitivity, an amplifier is included in the circuit. This is board E104. As a convenience, a jack (J-101) is provided so that the current in the apparatus under test can be metered or monitored by an external device such as a recorder.

Line voltage transients may cause the megohm indicating meter pointer to swing widely, interfering with resistance measurement. A meter damping switch S102 and a capacitor C104 are provided so that by placing the damping switch in the IN position (closed), the capacitor will increase the meter damping and cause the meter to integrate and slow the pointer swings. When the meter damping switch is in the OUT position, minimum integration occurs and the motion of the meter pointer is normal. (See Section H and I for additional information).

The guard terminal is used to bypass current around the megohm indicating meter. (This feature is described in Sections H, I, and J.)

The separate ground lead W102 provides a ground for the Test Set panel and a current return path from the apparatus under test through the megohm indicating meter.

Output voltage is controlled by the variable autotransformer T101, by altering the voltage to the primary of transformer T102.

Complete circuit protection is provided by the two-pole circuit breaker K101 which also serves as the ON/OFF switch. The two-pole circuit breaker provides protection to T101 so that under all overload circumstances at least one pole will have a current overload. If either circuit breaker pole is tripped by overload, both poles will open.

Power is supplied to the test set through the three-conductor, permanently attached input cable W100. The green wires of this cable conform to electrical code requirements and provide a panel ground connection.

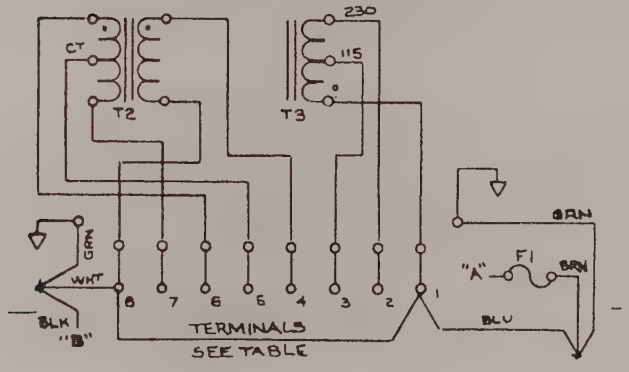
This test set has a zero-start safety feature requiring that the voltage control be set to zero in order for the advance of the output control to develop an output voltage. This feature is a function of control relay K102, whose contacts remain open after the power source is connected and after circuit breaker K101 is closed. This prevents the application of voltage to the input of T101 until the contacts of K102 are closed by the zero positioning of T101. When the contacts are closed, relay K102 is sealed; and the contacts remain closed until power is removed by opening K101 or by removing the line cord from the outlet. In order to re-establish output, power must again be applied and the voltage controls set to zero.

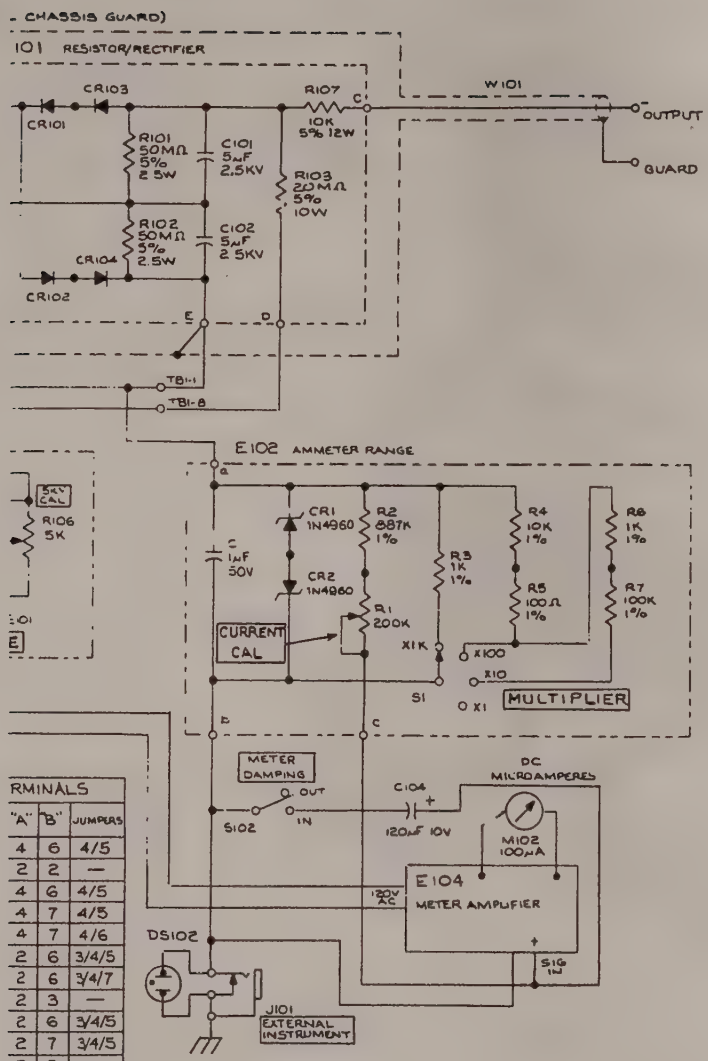
Power Supply Option

Test sets equipped with the -47 optional input differ from standard sets in that separate step-down transformers T2 and T3 are included between the power source and the test set. The nominal line voltage is specified at purchase. Transformers are located in the bottom of the test set.

Optional output voltages may be selected in accordance with the following table:

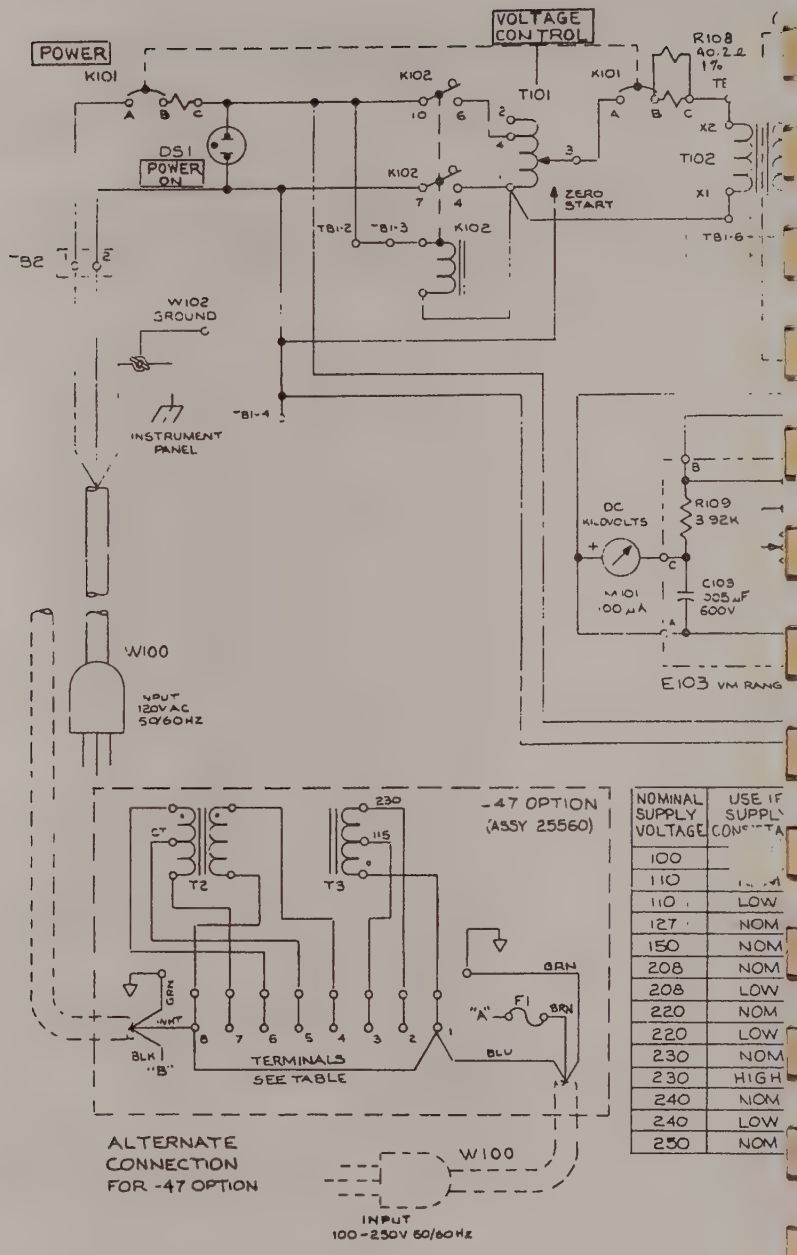
NOMINAL SUPPLY VOLTAGE	USE IF SUPPLY CONSISTANTLY	TERMINALS			
		F1	"A"	"B"	JUMPERS
100	NOM	3	4	6	4/5
110	NOM	3	2	2	—
110	LOW	3	4	6	4/5
127	NOM	3	4	7	4/5
150	NOM	3	4	7	4/6
208	NOM	1½	2	6	3/4/5
208	LOW	1½	2	6	3/4/7
220	NOM	1½	2	3	—
220	LOW	1½	2	6	3/4/5
230	NOM	1½	2	7	3/4/5
230	HIGH	1½	2	3	—
240	NOM	1½	2	3	—
240	LOW	1½	2	6	3/4/5
250	NOM	1½	2	3	





RMINALS		
"A"	"B"	JUMPERS
4	6	4/5
2	2	—
4	6	4/5
4	7	4/5
4	7	4/6
2	6	3/4/5
2	6	3/4/7
2	3	—
2	6	3/4/5
2	7	3/4/5
2	3	—
2	3	—
2	6	3/4/5
2	3	

Figure 1: Schematic Diagram of the 2.5/5 kV Megohmmeter Test Set.



NOMINAL SUPPLY VOLTAGE	USE IF SUPPLY CONNECTED
100	
110	
110	LOW
127	NOM
150	NOM
208	NOM
208	LOW
220	NOM
220	LOW
230	NOM
230	HIGH
240	NOM
240	LOW
250	NOM

SECTION F

CONTROL AND CONNECTOR IDENTIFICATION

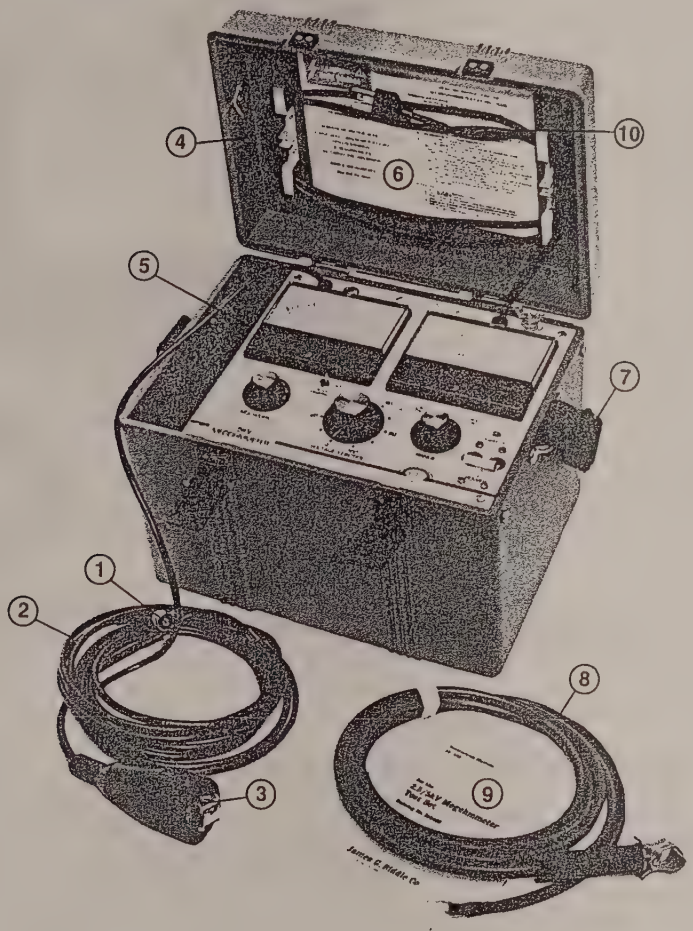


Figure 2A

1. Guard Terminal
2. Output Cable
3. High Voltage Terminal
4. Removable Case Cover
5. Serial Number
6. Instruction Card
7. Carrying Strap
8. Ground Cable
9. Instruction Manual
10. Input Cable

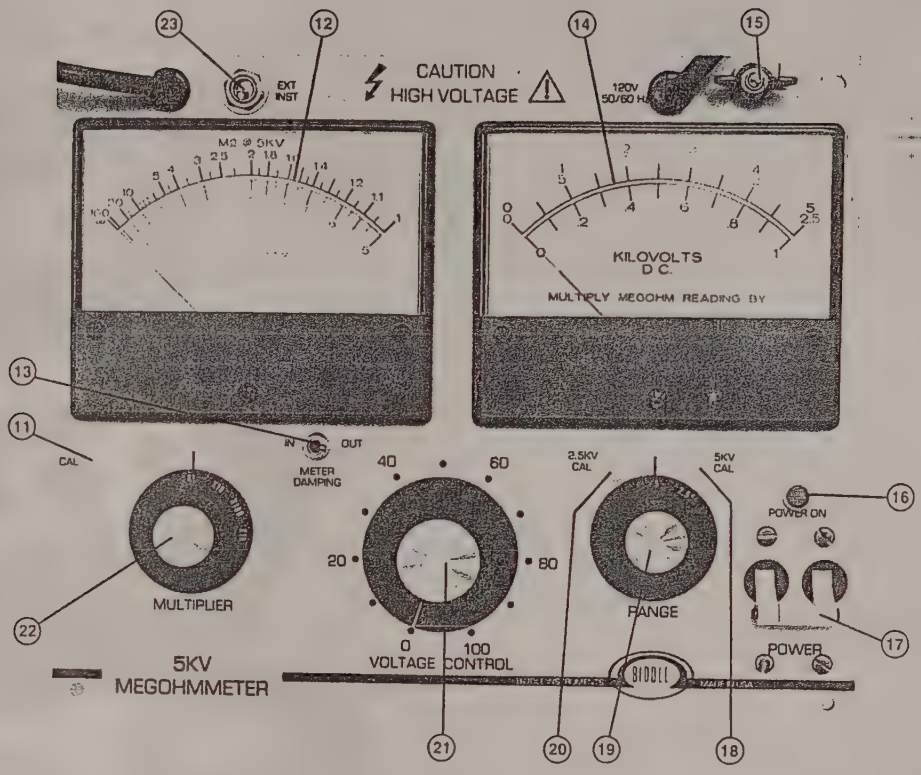


Figure 2B

11. Megohmmeter Calibrator
12. Megohmmeter
13. Meter Damping Selector
14. Kilovolt Meter
15. Panel Ground Terminal
16. Power ON Indicator
17. Main Power Switch
18. 5 kV Voltmeter Calibrator
19. Voltmeter Range Selector
20. 2.5 kV Voltmeter Calibrator
21. Voltage Control
22. Megohmmeter Multiplier Selector
23. External Instrument Jack

Figure 2: Views of the 2.5/5.0 kV Megohmmeter Test Set.

SECTION G

SETTING UP

The following steps are listed as a general guide for setting up the Megohmmeter Test Set. Suggested setup arrangements are shown in Figures 3A-3E. Test set controls and terminals are identified in Section F. Special instructions for test sets having 200 to 250-volt supply are on page G3.

PREPARATION

Before setting up the test equipment, read Section B of this manual. Working with due regard to safety, identify the terminals of the apparatus to be tested. Be sure that the low voltage terminal is securely grounded. Provide a ground connection, if necessary, using wire of 18 AWG or larger.

Place guard connections on the terminals if a guarded test is required. (See Section H and I). Set up barriers or use other means to keep unauthorized personnel away from all high-voltage terminals of the complete test arrangement.

SELECTION OF LOCATION

Select a location for the test set which meets the following conditions:

1. The operating area must be as dry as possible.

2. The test set must be within 15 feet of the high-voltage terminal of the apparatus to be tested.
   NOTE: For operator safety, the output cable should be fully extended to provide maximum distance between the operator and the high-voltage terminal.

3. A reliable ground connection must be within 10 feet of the test set.

4. An electrical service outlet must be within 5 feet of the test set.
   NOTE: An NEC approved extension cord rated for 15 amperes (minimum) and not longer than 50 feet may be used when required.

5. The operator of the test set must be able to conduct the test without being exposed to traffic hazard; and he must have free access to all controls and be able to read the meters and panel markings easily without approaching energized high-voltage terminals.

CONNECTION PROCEDURE

1. Connect the test set ground lead to the panel and to the local ground. Caution: For safe operation this separate ground cable must be used. The green wire of the input cable provides a parallel path but cannot be relied on to provide an adequate ground path for the panel.

2. Connect the output cable clip to the high-voltage terminal of the apparatus to be tested. (See below under Clearances.)

3. If guard is not in use the output cable shield must not be grounded. Grounding this shield will short-circuit the megohmmeter; the set, therefore, will not register a resistance measurement.

4. If a guarded test is to be run, connect the guard lead of the apparatus to be tested to the shield of the output cable. (See Sections H and I.) Insulate the guard circuit from ground.

5. With the test set switch OFF, connect the input cable to the service outlet.

CLEARANCES

Be sure adequate clearances are maintained between energized conductors and ground to prevent arc-over. Such accidental arc-over may create a safety hazard or damage the equipment being tested. The position of the exposed conductors with respect to ground can often be maintained by tying the conductors in place with clean, dry nylon rope. Table I lists the minimum air clearances that must be maintained and also suggests the minimum path length along a rope if it is tied directly to a conductor. Finally, the table indicates minimum personnel clearances (based on OSHA specifications) that will limit the danger of static induced voltages being developed on nearby insulated objects, including people.

TABLE 1. MINIMUM AIR CLEARANCES

Voltage of Test	Direct Air Path (inches)	Path Along Dry Nylon Rope (inches)	Minimum Personnel Clearances (feet)
5 kV	0.5	1-1/8	2
10 kV	1.0	2-1/4	2

After completion, make a careful review of the test setup. Tests can then be conducted per Section H. For convenience a condensed operating procedure is given on the Instruction Card.

POWER SUPPLY OPTION, Catalog No. 210400-47

When this option is supplied, Biddle Instruments recommends that the service supply be limited by an appropriate line fuse to provide protection in case of a malfunction of the stepdown transformer. Providing this protection is the responsibility of the user. A fuse of not less than 1-1/4 amperes nor more than 3 amperes is recommended.

Because of the many different service sockets in general use, the input cable has been provided with a plug for which adaptors are readily available. If use of an adaptor is not desirable, the plug supplied can be cut off and replaced with one best suited to the service conditions. The green lead of the input cable is to be connected to ground, the white lead to the supply neutral, and the black lead to the "hot" portion of the line.

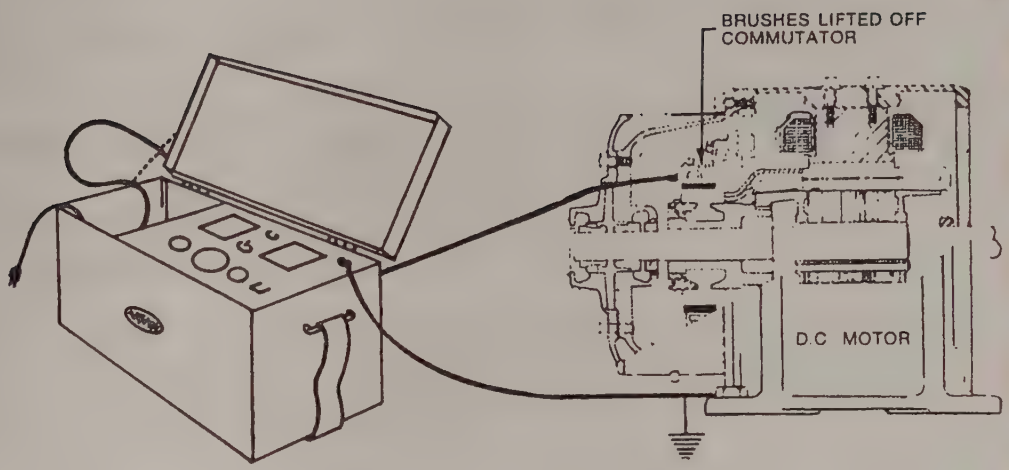


Figure 3A: DC Motor Test Setup.

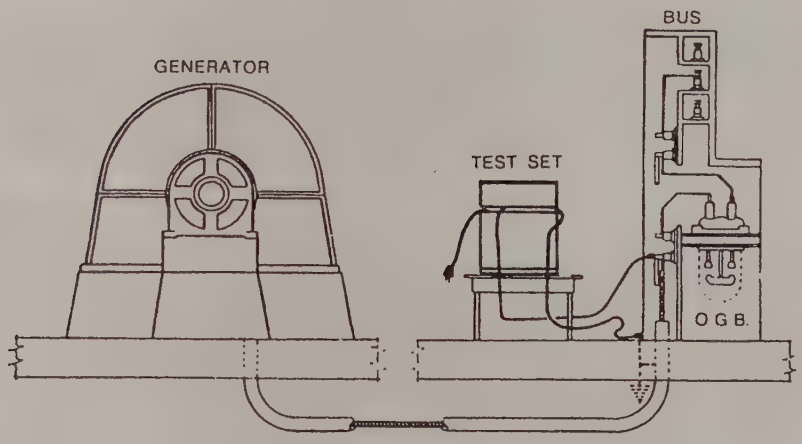


Figure 3B: Generator Test Setup.

SECTION H

OPERATION

Before conducting a test, consult Section B on Safety, Section C for test details and Section J for test theory.

When the test set and apparatus to be tested are set up as indicated in Section G, the equipment can be energized and the required tests run by following the steps given below on the next page.

TEST PROCEDURE (Following procedure of Section G)

1. Remove all safety grounds from the apparatus to be tested.
2. Close the main switch of the test set. *
3. Firmly set the voltage control to zero.
4. Turn the voltage control clockwise to increase the output voltage as required for the test being conducted.
5. Note voltage, resistance, and time as required by the test procedure being followed. Make settings and take readings as described in steps 7, 8, or 9.
6. If the indicated resistance fluctuates during the reading, the meter damping switch may be set to the IN position. (Normally the meter damping switch is in the OUT position undamped.)
7. To measure the insulation resistance at 5kV, set the voltmeter range switch to 5kV and set the output voltage to exactly 5kV. Read the upper megohm scale (black) of the megohmmeter. Multiply value read by the multiplier to which the megohmmeter range switch is set (i.e., by 1, 10, 100, or 1000). (See Section I.)
8. To measure insulation resistance at 2.5kV, set the voltmeter range switch to 2.5kV and set the output voltage to exactly 2.5kV. Read the lower scale (red) of the megohmmeter. Multiply the value read by the multiplier to which the megohmmeter range switch is set (i.e., by 1, 10, 100, 1000). (See Section I.)
9. To measure insulation resistance at voltages other than 2.5kV or 5.0kV, read the megohmmeter, using the upper scale if the voltmeter range switch is set to 5kV or the lower scale if the voltmeter range switch is set to 2.5kV. Multiply the megohm scale value by the multiplier to which the megohmmeter range switch is set to obtain the indicated megohm value. Multiply the indicated value by the factor read from the lower voltmeter scale (green) to obtain the true insulation resistance. (See Section I.)

* If the service outlet voltage exceeds the rated limit for the test set the Power ON indicator will be abnormally bright. This will warn and alert the operator to stop the procedure and correct the problem.

BREAKDOWN OF TEST ITEM

In the event of failure of the apparatus being tested, the test set circuit breakers will trip out within twenty (20) seconds. When such a tripout occurs, before approaching the equipment, apply the grounding stick to the high voltage terminal to discharge the test setup, as all stored energy may not be dissipated by such a failure.

NORMAL SHUTDOWN PROCEDURE

When the test has been completed, follow the shutdown procedure:

1. Set the voltage control to zero.
2. Open the main circuit breaker (main switch).
3. When the voltmeter indicates that voltage has decreased to a value of less than half the voltage used during the test, use an insulated grounding stick to apply a direct short circuit to all ungrounded terminals of the apparatus being tested.
4. Disconnect cables in the following sequence; first, the input cable; second, the output cable (including the guard if in use); finally, the ground cable.
5. Apply ground bonds to the equipment that has been disconnected.

INTERRUPTING A TEST

At any time, the main switch (circuit breaker) can be opened manually to interrupt a test, provided that the grounding stick is applied afterward to discharge any stored energy as described in the normal shutdown procedure.

For any circumstances requiring that a test be stopped immediately, the procedure is to apply the grounding stick directly to the high-voltage terminal. This action will remove the test voltage in the shortest possible time and will in time trip out the circuit breaker. This procedure should be followed only when absolutely necessary since there is a risk of damage to both the test set and the apparatus being tested.

SECTION I

OPERATION NOTES

LINE SUPPLY

When operation requires a temporary service, the operator should verify the voltage and overcurrent protection at the service outlet for the test set prior to plugging in the test set.

The Biddle Co. recommends that when using the Cat. 210400-47 the service supplying the test set be protected by a fuse of not less than 1-¼ ampere or more than 3 amperes. The Cat. 210400-47 has been supplied with a line cord connector for which adapters are readily available to fit the many different service outlets in use. The connector may be cut off and replaced with the fitting used in the service area if desired. The green lead must connect to service ground. The white lead to the supply neutral and the black lead to the "hot" lead of the supply.

METER RANGE SETTINGS DURING TRANSIT

The meters included in this set are of rugged construction; but it is recommended that during transportation of the test set the meter range switches be set to the highest range, the voltmeter to 5 kV, and the megohmmeter to x1K and the Meter Damping Switch placed in the IN position.

MEGOHM READINGS

The megohmmeter is a current meter measuring the current passing through the item under test, but calibrated in megohms. The relation between current and megohms (resistance R) is expressed by Ohm's law:

$$R = \frac{V}{I}$$

The meter calibration depends on both the current, I, and the test voltage, V. Therefore, each megohm scale applies only when the test voltage is set to the correct value. In the Cat. 210400 two megohm scales are provided, one (black) for a test voltage of 5kV, and one (red) for a test voltage of 2.5kV. These voltages are used because they are called for in dc testing of commonly encountered services. For best accuracy the voltmeter has each of these voltages as full scale values.

Resistance at any other test voltage within the range of the Cat. 210400 can be computed by the following:

$$R_V = R_{FS} \times \frac{V}{V_{FS}}$$

where V = actual test voltage

V_{FS} = the selected voltmeter full scale (2.5 or 5.0 kV

R_{FS} = megohmmeter reading corresponding to V_{FS}

R_V = the actual measured resistance at voltage V

For simplicity the factor $\frac{V}{V_{FS}}$ can be read directly from the lowe

(green) scale of the voltmeter or is easily computed.

Note that when the test voltage is set to full scale as in the usual usage, V holds for this case but the factor $\frac{V}{V_{FS}}$

becomes numerically unity (1) so the following rule holds for all situations
Resistance at any test voltage within the range of Cat. No. 210400.

1. Read megohms on the scale corresponding to the voltmeter range
2. Multiply by the megohmmeter range setting.
3. Multiply by the reading from the voltmeter lower (green) sc

CORRECTION FOR INTERNAL LEAKAGE

If the insulation resistance is high, arbitrarily over 20,000 megohms a more accurate measurement can be made by correcting for the interna leakage of the test set.

To do this first suspend the output terminal well clear of all object and raise the voltage to the value required by the test. Read the resulting leakage resistance.

Make the required resistance measurement, then use the equation:

$$R_T = \frac{R_L \times R}{R_L - R}$$

where R_L = measured leakage resistance (typically 100,000 megohms)

R = measured resistance of item under test

R_T = corrected measured resistance of item under test

METER DAMPING SWITCH

In most cases the motion of the Megohmmeter pointer is slow and steady enough to permit a decisive megohm reading.

In certain cases the Megohmmeter pointer will be observed to swing rapidly and widely so that a decisive resistance reading cannot be made. This condition happens when the item under test has significant capacity and resistance values on the order of thousands of megohms. It is the result of line voltage transients that cause small changes in the test voltage.

When the resistance reading is indecisive the Meter Damping Switch S104 can be placed in the IN position. This connects the integrating capacitor, C104 across the Megohmmeter circuit. This action causes the Megohmmeter to integrate. The integration slows down the pointer swings and reduces the amplitude of the swings so that a more decisive average reading can be made. The average value of resistance measured approximates the true value.

In critical testing it may be desirable to supply the Test Set from a line voltage regulator, especially if the test in use requires resistance to be observed over long (many minutes) periods of time or if such measurements are to be used to compare tests made several months or years apart.

USE OF GUARD (See Section J)

Occasionally when measuring apparatus, the leakage resistance of interest is masked by a parallel path. Such a situation is often encountered when measuring the leakage resistance of a cable. In the practical situation, the value of the resistance along the leakage path from the conductor over the surface of the pothead may be less than that within the major length of the cable. Under such conditions the guard feature of the test set is useful in excluding the resistance of the surface path from the measurement. (See Figure 4.) This is easily accomplished by forming an intercepting electrode by wrapping a wire around the outer surface of the cable pothead insulation close to the cable shield or ground. This electrode, which will intercept the surface current, must be connected to the test set guard terminal. The unwanted current then bypasses the megohm indicating meter and is not measured; the meter will read only the insulation resistance of the main portion of the cable.

The same guard principle can be used on other apparatus (Fig. 5) where a suitable intercepting electrode can be added on a temporary basis. On some kinds of apparatus, notably bushings, the guard electrode is built in. The guard terminal is only a few volts above ground and does not pose a safety hazard; however, it must not be grounded.

VOLTAGE CONTROL SCALE

A reference scale is provided so that the voltage control position can be repeated. This convenience feature is useful when making repetitive tests, such as those required on the three-phase wires of a cable. In addition, the voltage control scale also is used to predetermine the voltage developed even though the actual voltage buildup may lag behind the motion of the voltage control because of the capacitance charging effect. Using this feature minimizes the possibility of applying excessive voltage to the apparatus being tested.

To predetermine the voltage control setting, refer to the regulation curve given in Figure 6. The accuracy of the voltage setting will normally be on the order of 5 to 10%, depending on the line voltage and the nature of the apparatus being tested.

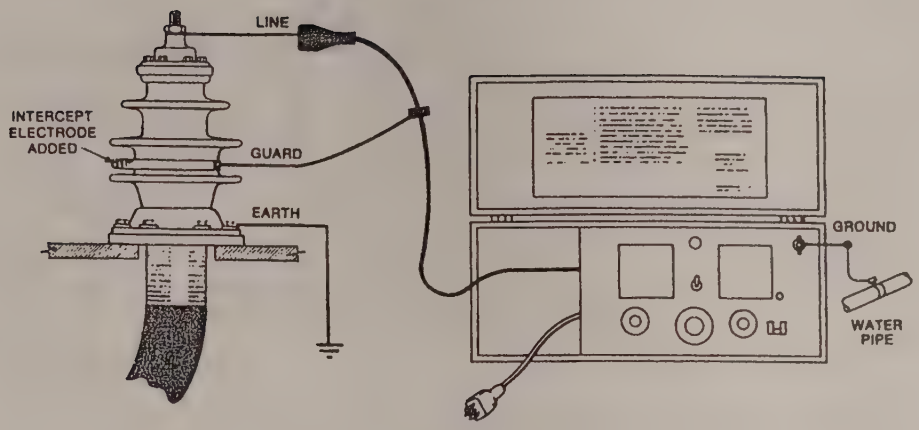


Figure 4A: Typical Guard Connection to Cable Pothead.

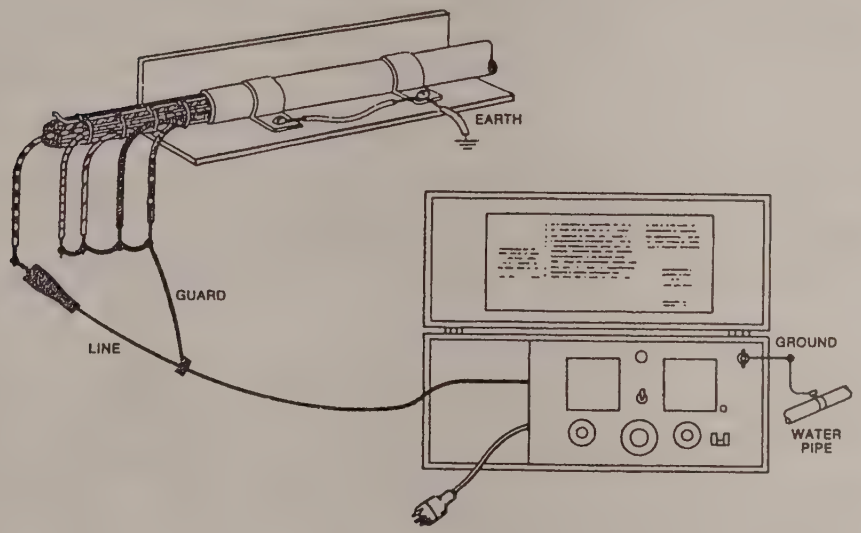


Figure 4B: Guard Connection for a Typical Cable Test.

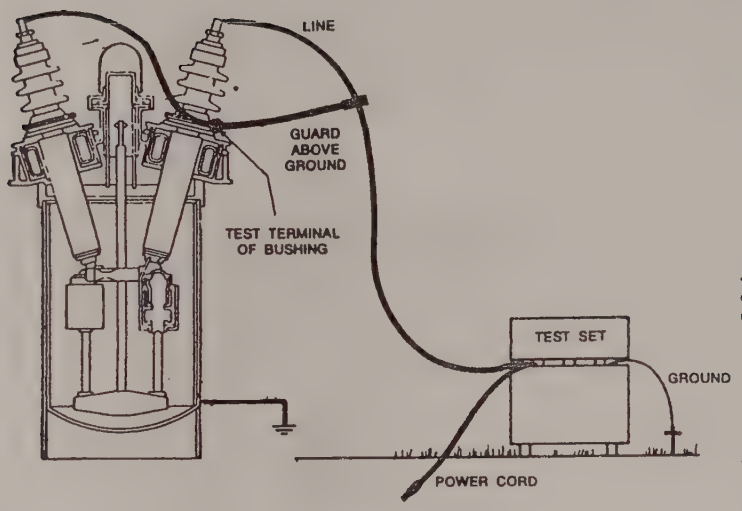


Figure 5A: Typical Guard Connections for an Oil Circuit Breaker.

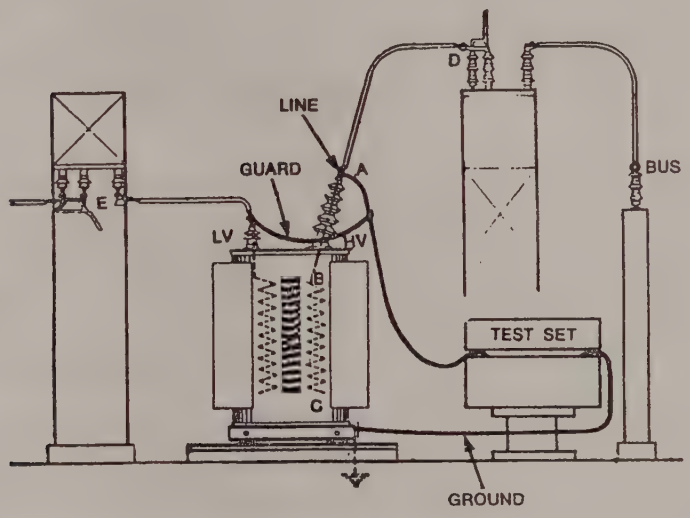


Figure 5B: Typical Guard Connection for Transformer Test.

USE OF REGULATION CURVE

The regulation curve given in Figure 6 has been provided for convenience in planning the adaptation of the test set to measurement of various apparatus. It is also useful in adapting the test set to special use such as production testing. The regulation curve relates the output voltage control setting to the actual output voltage and current or load resistance. From this curve, peak ripple voltage can be estimated and the equivalent internal resistance of the test set can be estimated for a wide variety of circumstances. The curve also indicates the circuit breaker limits of operation.

STEP VOLTAGE TESTING

This test set is well adapted to the commonly used test procedure of increasing the voltage applied to the apparatus being tested in steps. (See Section J for additional data). The regulation curve given in Figure 6 is useful for estimating in advance the voltage control position for each step. Then during the test, the control can be advanced to the next predetermined setting. This procedure gives the sharpest step change in voltage and provides better test results than if the control is inched to the next step.

FAULT LOCATING (BREAKDOWN TESTING)

In practice, if the apparatus being tested fails, the user may be faced with the problem of locating the failure so that repairs can be effected. Often the failure occurs in the form of an arc-over; that is, the apparatus will support some voltage, but above this level a spark forms at the failure, the voltage collapses, and the current soars.

This will usually trip out the test set; but if the voltage control is set just beyond the voltage that causes arc-over, it is possible that the arc-over will repeat several times before trip out. During this time, the operator can look for the light and noise generated by the spark and so locate the fault. Arc-over can be induced quite deliberately without damage to the test set; it is even possible to place some resistance in series with the high voltage connection and allow the arc-over to periodically repeat and continue for long periods of time. In some cases, however, this result can be obtained simply by careful adjustment of the voltage control.

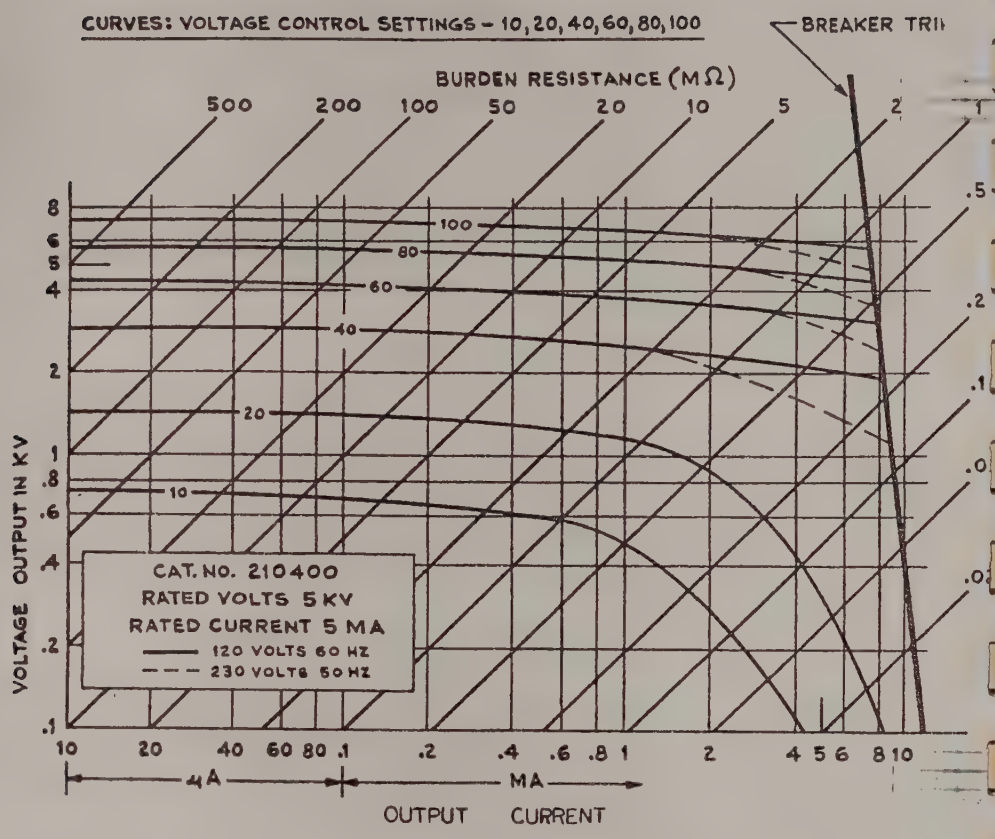


Figure 6: Regulation Curve.

This test set is not recommended for locating faults in long cables; but it may be used occasionally for cable fault locating on short cables (on the order of 1000 ft. or less) that arcover at voltages of less than 3.0kV.

In any case, when used for this purpose the test set can continue, for long periods, to generate arc-overs at a rate not exceeding one discharge every three seconds. Attempts to shorten this time interval may result in trip out. Trip-out warns that the thermal limit of the components will shortly be reached unless the discharge rate is reduced by lowering the voltage or adding series resistance. When series resistance is added, care must be taken to avoid hazards from the new connection.

SECTION J

APPLICATION NOTES

Theory of Insulation Testing

Any device that uses electrical energy can ordinarly be considered as consisting of elements that may be classified in two separate categories namely, those parts of the apparatus that conduct the electrical energy and those parts that are not intended to conduct. It follows that any such apparatus includes an insulation system that is not intended to conduct electrical energy but which is under electrical stress. If such insulating parts do become conductive, the apparatus will fail. Electrical insulation can be tested by a variety of methods and measurements may be taken to anticipate such failures. Each method has its own merits; but one technique is to apply a dc voltage to the insulation system and measure such quantities as the applied voltage, the leakage resistance, and the manner in which such quantities vary with time. These dc test techniques have been well developed over many years, and considerable literature exists on this subject. Detailed information on dc testing is also available in a course entitled "DC Testing of Power Apparatus Insulation" offered by the Biddle Instruments Technical School.

The few references given below are not presented in any special order, and no particular preference is implied; they are included merely for the convenience of the user so that he may make full use of this dielectric test set.

Insulation Testing by DC Methods. Biddle Technical Publication 22T1a 1975

Fink, Donald G. and Carroll, John M. Standard Handbook for Electrical Engineers (New York: McGraw-Hill, 1968)

Guide for Testing Insulation Resistance of Rotating Machinery, IEEE Standard 43.

Guide for Insulation Maintenance for Large Alternating Current Rotating Machinery. IEEE Standard 56.

Guide for Making Dielectric Measurements in the Field. IEEE Standard 62.

Guide for Insulation Testing of Large AC Rotating Machinery with High Direct Voltage. IEEE Standard 95.

APPLYING THE TEST SET

The Test Set measures the test voltage and the resistance of the item under test; the operator must introduce the time parameter into the test.

For safety reasons one terminal of the Test Set must be connected to ground. One side of the apparatus being tested must be connected to ground. This minimizes exposure of high voltage leads and conforms to the way most apparatus is constructed. This leaves one terminal at high voltage and for dc test sets this high voltage lead is usually negative with respect to ground.

The Test Set measures the test voltage and the resistance of the item connected across the two output terminals, that is, the high voltage terminal and ground.

For most purposes the two-terminal resistance measurement is all that is required since all paths between High Voltage (Line) and Ground (Earth) are simultaneously measured and a total resistance value is found.

There are certain important practical situations where a two-terminal measurement does not convey the desired information.

In Section I the guard was recommended when testing cable. In practical application this arrangement can resolve the problem that the dirty surface path over the pothead may conduct more current t ground than actually passes through the bulk of the cable itself. The practical result is that the cable appears to have a relatively low resistance while in fact the cable itself is acceptable but the pothead is not.

By making an unguarded, then a guarded test it is possible to determine if the cable or the pothead is at fault thus indicating the appropriate action to be taken.

The principle of making more than one measurement with and without guard can be extended to other apparatus in order to separate multiple resistance paths and so better analyze the situation.

In some literature the unguarded measurement is called a two-terminal measurement while the guarded measurement is called a three-terminal measurement.

The principle of combining 2 and 3 terminal measurements is often used when the path of interest does not have the required ground on one terminal in order to make the necessary measurement.

Application of Combined 2 and 3 Terminal Measurement

A two winding transformer in a grounded metal case with the core also grounded is a common construction having the typical problem of measurement of an ungrounded resistance path. Frequently it is desirable to measure the insulation resistance between each winding and ground and the insulation resistance between the windings. In Figure 7 this case is shown schematically.

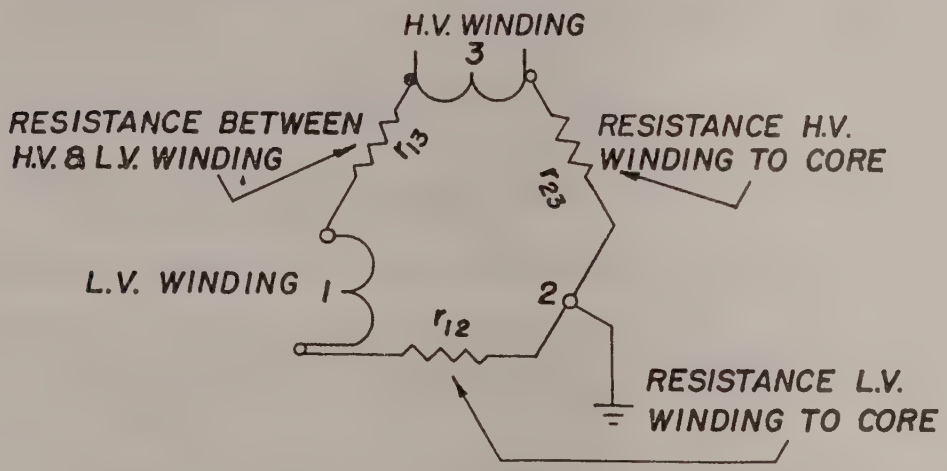


FIG. 7

TWO-WINDING TRANSFORMER IN THREE-TERMINAL FORM

The measurements required are a combination of 2 and 3 terminal forms and measurements of resistance are made in accordance with Table II.

	CONNECTIONS		
MEASUREMENT	HIGH VOLTAGE	GROUND	GUARD
r'_{12}	1	2	Not Used
r_{12}	1	2	3
r_{23}	3	2	1

TABLE II

$$r_{13} = \frac{r'_{12}(r_{12}+r_{23}) - r_{12}\cdot r_{23}}{r_{12}-r'_{12}}$$

By using guard the resistance between each winding and ground are measured directly and with the addition of one extra measurement the resistance between windings is calculated from the above equation.

NOTE: There are alternate forms possible for the desired equation and measurement table.

Generalized Combined 2 and 3 Terminal Measurement

The schematic of Figure 7 can easily be reduced to the equivalent delta connected resistors with one junction grounded. Many problems can be reduced to this form and then evaluated by the technique given above. The additional effort required to carry out the study to reduce the problem to a grounded delta form and then perform the necessary measurements are often justified for a preventive maintenance program that compares measurements made at long intervals, such as yearly. Another justification is usually related to how important the apparatus is and how reliable it must be.

SECTION K

ROUTINE MAINTENANCE

Field service subjects high-voltage test equipment to a difficult environment, but equipment wear can be minimized by periodic inspection and cleaning. Such inspections and cleaning also will ensure reliable on-the-job operation. The frequency of routine inspection and cleaning will depend on the field conditions encountered. As a guide, for sets operated indoors in a normally dusty atmosphere, this procedure should be performed once every six months; as an extreme, the procedure should be carried out monthly on a set that is used daily outdoors in a heavy dust concentration that is conductive and hygroscopic.

Prior to performing inspection and maintenance, consult any damage reports that may have been completed for the test set.

Inspection and Maintenance Procedure

Complete inspection and maintenance procedures can be performed in approximately fifteen minutes. The only equipment required consists of a screwdriver, an insulated jumper about one foot long, a clean damp cloth, and a clean dry cloth.

Proceed according to the steps given below.

1. Visually inspect the case, noting that hinges and case locks function properly. Check for breaks in the case or lid. Note the condition of the carrying strap and case feet.

2. Wipe the outside of the case with the damp cloth; then dry with a clean dry cloth.

3. Open the lid; fully extend and visually inspect all cables. If necessary, wipe each cable with the damp cloth; then dry. Wipe out the lead compartment. Wipe the panel and instruction card with a clean dry cloth.

4. Visually inspect the panel, noting that all knobs are secure on their shafts and that all controls operate smoothly without binding.

5. Set meters mechanically to zero.

6. Removal of Test Set from Case

> CAUTION!
>
> THE TEST SET MUST BE DEENERGIZED FOR AT LEAST FIFTEEN MINUTES BEFORE REMOVING FROM CASE.

The test Set should be removed from its case only by those traine in handling high-voltage equipment, since high voltage can b stored in components in the test set interior even after the se has been denergized.

To remove the test set from the case, follow the procedure give below.

A. Set aside the ground cable.

B. Remove and save the four panel screws and cup washers.

C. Raise the panel straight up to clear the case. Handle the se only by the panel. Place the set on a clean surface.

D. Using an insulated jumper, short-circuit capacitor C-101, the capacitor C-102 to remove any stored charge.

7. Completion of Inspection

A. Wipe the circuit card with a clean dry cloth to re..v accumulated dust. Wipe the interior of the case. Visuall inspect the interior connections and components.

B. Reinstall the set in the case.

C. Coil the leads and replace them in the lead compartment.

If defects are discoverd during this inspection, see Section L-fc repair procedures. If all is in order, the performance may b checked by following the procedure given in Section M.

SECTION L

TROUBLESHOOTING AND REPAIR

Biddle Instruments maintains a complete repair service and recommends that its customers take advantage of this service in the event of equipment malfunction. The instrument will be cleaned and excessively worn or damaged parts replaced. Following repair, the instrument will perform functionally like a new instrument, but the appearance will be substantially as returned. A new one-year warranty will be extended to those parts repaired.

For those users who prefer to make their own repairs, replacement parts are available from the factory. (Part numbers are given in Section N.) Those items which can be returned separately for repair are indicated in the parts list by an asterisk following the part number. Upon their return to the factory, such items will be repaired or replaced, whichever is less costly and returned to the user under the same conditions as new replacement parts.

Prior to shipment, all components supplied for field replacement are inspected to the same extent as those used in original equipment; but because of the possibility of associated component failure, Biddle does not warrant such assemblies. (Shipping damage, of course, is coverd by insurance claims.)

If the test set fails to operate properly, the information given in this section will be useful in determining the cause of the malfunction. Table III (included at the end of this section) notes possible equipment malfunctions that may be observed during operation or checkout and suggests possible causes and means of determining the defective component. Table III has been arranged to refer to the replacement part assemblies, as Biddle recommends that field repairs be made by replacing assemblies. The schematic diagrams in Section E and the interior view of the test set given in Figure 8 will be helpful in locating components. When ordering parts, always include the Test Set serial number. The location of the serial number is shown in Figure 2 (see Section F).

It is important that persons repairing the Test Set fully understand the operation of the circuitry. When an assembly fails, it may damage associated components and this possibility must be evaluated prior to replacing an assembly. The circuitry must also be understood so that measures may be taken to prevent shock hazard to those making repairs.

When making repairs to this test set or replacing components, the procedures outlined in the following paragraphs should be followed.

Remove the Test Set from the case as explained in Section K.

Case Repairs

Because of its construction, a damaged lid or lower case will require that both lid and lower case be replaced as a unit. The replacement case is supplied with the instruction card and all hardware so that the test set can simply be placed into it. The case feet,carrying strap, and strap loops are accessible for replacement after the test set has been removed from the case.

Replacement of Input Cable W-100 and Integral Plug P-101

1. Remove the test set from the case as indicated above.

2. Locate the input cable and disconnect each of its three wires, noting the terminal from which each lead is disconnected.

3. Squeeze the cable clamp and withdraw the cable and clamp from the chassis. Save the cable clamp.

4. Place the cable clamp on the new cable in the same position as on the original cable.

5. Reinstall the cable in the chassis, dress the leads, and terminate on the original points.

6. Reinstall the test set in the case.

7. On -47 sets the input cord is part of the transformer assembly (T102) which is then connected to the test set with a shortened cord. The input cord to the transformer may be replaced as above.

Replacement of Output Cable W-101

1. Remove the test set from the case.

2. Locate the output cable and disconnect it from the circuit, carefully noting lead dress and terminals.

3. Squeeze the cable clamp, and withdraw the cable and clamp from the chassis.

4. Duplicate the original test set cable end terminations on the new cable, and place the cable clamp in the same position as on the original cable.

5. Reinstall cable and clamp in the case; dress the cable into position, and terminate at the original points.

6. Reinstall the test set in its case.

Replacement of Panel Mounted Assemblies

A. Disconnect the panel harness from the chassis terminal block. Note the location of each lead so that it may be reconnected to the same point.

B. Remove the panel and follow the steps below:

Replacement of Meters or Meter Amplifier Board

1. Place the panel on a clean cloth with the meters face down.

2. Remove the leads and note the terminals to which they should be reconnected.

3. Remove amplifier board if necessary.

4. Remove the four nuts and washers on the meter studs.

5. Slide the meter from the panel.

6. Replace the meter and reverse the above steps to complete the repair.

Replacement of Megohm Meter Range Circuit

1. Remove the range switch knob, switch shaft, locknut and washer.
2. Unsolder the three leads attached to the E-102 circuit card, noting the proper reconnection terminals for each lead.
3. Install the new E-102 assembly.
4. Tighten the switch shaft nut.
5. Replace the knob so that the numbers line up with the panel index lines. Be sure that all steps are aligned.
6. Resolder the leads to the printed circuit card.

Replacement of Voltmeter Range Circuit

1. Remove the voltmeter knob and the switch bushing nut.
2. Unsolder the threee leads, noting where each one terminates.
3. Replace the switch assembly and tighten the switch bushing nut.
4. Replace the knob, align it with the panel index, then tighten the knob on the shaft.
5. Resolder the leads to the printed circuit card.

Replacement of Meter Damping Switch S-102

1. Unsolder the two leads from the back of the switch, noting the terminals to which each wire was connected.

2. Remove the switch nut from the front of the panel.

3. Replace and align the switch, and lock it in place.

4. Resolder the two leads.

Replacement of Damping Capacitor C-104

1. Unsolder the two leads to this capacitor, noting the terminals to which each wire is attached.

2. Cut the tie-wrap holding the capacitor (note the polarity).

3. Install the replacement capacitor on the bracket, using a new tie-wrap to secure the capacitor in the same position and with the original polarity.

4. Reconnect and resolder the leads to the capacitor terminals.

Replacement of Lamp DS-101

1. Unsolder the two leads from this lamp, noting carefully the terminals to which each lead was connected.

2. Using a knife blade and needle-nose pliers, remove the holding clip.

3. Install the replacement lamp, pressing the clip into place to hold the lamp securely in the panel.

4. Reconnect and resolder the leads.

Replacement of Main Breakers

1. Remove the "C" rings holding the cross member between handles, and remove the cross member.

2. Disconnect all terminals, carefully noting the terminal to which each lead must be reconnected.

   NOTE: A resistor will be found across two of the circuit breaker terminals. Certain circuit breakers have the trip value trimmed by such a resistor; it may not be present on the replacement, but it is required.

3. Remove and save the four front panel screws.

4. Install the replacement breaker and secure it to the panel, making sure that it closes when the handle is moved toward the lid.

5. Reinstall the cross member between the handles.

6. Reconnect all leads to the appropriate terminals.

Replacement of Voltage Control Autotransformer T-101

1. Disconnect all leads, noting the appropriate reconnection terminal for each.

2. Remove the voltage control knob.

3. Remove the bushing nut.

4. Pull the transformer free of the assembly.

5. Replace the transformer through the panel.

6. Tighten the panel nut.

7. Reconnect the wires.

8. Install the knob and check its alignment at zero and full scale, then tighten.

Replacement of the K-102 Assembly

1. Disconnect relay K-102, noting the appropriate reconnection terminals for each wire.

2. Remove K-102 from the panel bracket.

3. Replace K-102.

4. Reconnect relay K-102.

Replacement of Chassis Mounted Assemblies

To replace chassis mounted assemblies, remove the panel, following the procedure given above, and short-circuit the two capacitors, then follow the appropriate steps given below.

Replacement of Card E-101

1. Remove the three leads from the terminal strip, noting the proper reconnection terminal for each lead.

2. Remove the four nuts from capacitors C-101 and C-102.

3. Remove the output cable terminal by removing the screw which connects it to resistor R-107.

4. Raise the card, folding it out so that the transformer lead can be unsoldered.

5. Unsolder the lead, noting the appropriate reconnection points.

6. Replace the card and resolder the transformer lead to the replacement card.

7. Reverse the disassembly procedure to complete the installation.

Replacement of Transformer T-102

1. Follow the procedure for removing card E-101.
2. Disconnect the transformer leads from the terminal strip and chassis.
3. Remove the terminal strip. Save the spacers that hold the terminal strip clear of the chassis.
4. Remove the transformer.
5. Reverse this procedure to install the replacement. Make sure to replace the spacers under the terminal strip.

Replacement of Capacitors C-101 and C-102

1. Follow the instructions for removing card E-101.
2. Loosen the capacitor brackets and open the securing band.
3. Remove the capacitor(s).
4. Replace with new unit(s) and resecure band and bracket.
5. Set the terminal nuts so that card E-101 is parallel to the chassis.

6. Re-install the E-101 card and proceed as for replacement of E-101.

Recalibration of Voltmeter

This procedure requires a dc meter that is capable of reading both 2.5kV and 5kV with an accuracy of ±1% or better. On either range this standard instrument should draw less than 0.5mA.

1. Connect the Test Set as shown in Figure 10.
2. Remove the cover screws from both the 2.5kV CAL and the 5kV CAL adjustments.
3. Operate the Test Set (Reference Section H).
4. Adjust the output voltage until the standard voltmeter reads 2.5kV with the test set voltmeter range switch set for 2.5kV.
5. Using a fine blade screwdriver, adjust the 2.5kV potentiometer through the 2.5kV CAL hole until it agrees with the standard.
6. Check at half-scale, then repeat on the 5kV range.
7. Replace both CAL cover screws.

Recalibration of Megohmmeter

Calibration accuracy is a function of the voltmeter accuracy. If voltmeter tolerance is questionable perform the recalibration of the voltmeter prior to recalibrating the megohmmeter.

This operation will require a current meter to measure dc. The meter must be capable of reading 0.5 mA with an accuracy of ±1% or better. A testing resistor of 2 megohms ±20% that is able to withstand 1000 volts will be required. (Recommend 2 resistors P/N 4694-8 connected in parallel).

1. Connect the Test Set as shown in Figure 9.
2. Operate the Test Set (Reference Section H).
3. Set the megohm meter range switch to X10.

4. Set the voltmeter range switch to 2.5kV.

5. Increase the output voltage to approximately 1kV so that the standard current meter reads 0.50mA.

6. Adjust the test set calibrator (MΩCAL) so that the megohmmeter reads 0.5 on the lower scale. To make this adjustment, remove the MΩCAL cover screw, and use a fine blade screwdriver to remove the calibration control.

7. To check for tracking, reduce the voltage until the standard current meter reads 0.25mA. The megohmmeter should then read 1.0 on the lower scale. Readjust MΩCAL for the best compromise.

8. To test the X1 range:

   a. Set the controls for a standard current meter current of 0.5mA, with the megohmmeter range switch set to X10 on the test set.

   b. Move the range switch to X1.

   c. Readjust the standard current if required, and note that the test set megohmmeter reads 5.0 on the lower scale.

9. To test the X100 range:

   a. Set the standard current to 50μA.

   b. Move the megohmmeter range switch to X100.

   c. The test set megohmmeter should read 0.5 megohms on the lower scale.

During this recalibration procedure, if a large change is required in the MΩCAL adjustment, the meter or its protective circuit may be defective. This should be investigated since the MΩCAL adjustment cannot compensate for errors on the X1K range.

For critical applications requiring certification or a more complete checkout of this test set, a special resistance box is available. If this checkout box is required, contact the factory for information about price and delivery.

TABLE III TROUBLESHOOTING GUIDE

Malfunction	Possible Cause
POWER ON lamp does not light.	Deenergized service outlet. Defective service outlet. Defective line cord. Defective lamp.
POWER ON lamp abnormally bright.	Supply voltage too high.
Main Breaker trips on closure.	Cross link between poles broken. Defective zero start circuit. Defective voltage control autotransformer. Wiring defect
Main breaker trips when output voltage is increased.	Test set output shorted. Defective output cable. Defective rectifier assembly. Defective filter capacitors. Defective high-voltage transformer. Defective voltage control autotransformer. Defective high-voltage insulation.

TABLE III (Cont'd.)

No output voltage.	Defective zero start circuit. Defective rectifier assembly. Defective high-voltage transformer. Defective voltage control transformer. Defective voltmeter movement. Defective voltmeter range selector/protective circuit. Defective voltmeter multiplier. Wiring defect.
No output current	Current range switch set too high. Guard circuit grounded. Defective current meter movement. Defective range selector/ protective circuit. Defective damping capacitor (only when in use). Wiring defect.
Output voltage erratic.	Equipment under test failing. Defective output cable (open circuit or poor connection). Defective voltage control autotransformer.

TABLE III (Cont'd.)

Output voltage setting does not agree with regulation curve.	Improper line supply voltage. Defective resistive load bank. Voltage control knob not in proper position on auto-transformer shaft. (See "No output voltage" malfunction.) Defective output resistor.
Output voltage greater than 500 volts at voltage control zero.	Defective setting of zero start contact. Defective output voltage control autotransformer
Current leakage greater than 0.3 μA at 5 kV no load.	Output terminal of output cable not properly spaced from nearby objects. Output terminal dirty. Output terminal burred or damaged. Internal dirt or damage. (See "No output voltage" malfunction.)

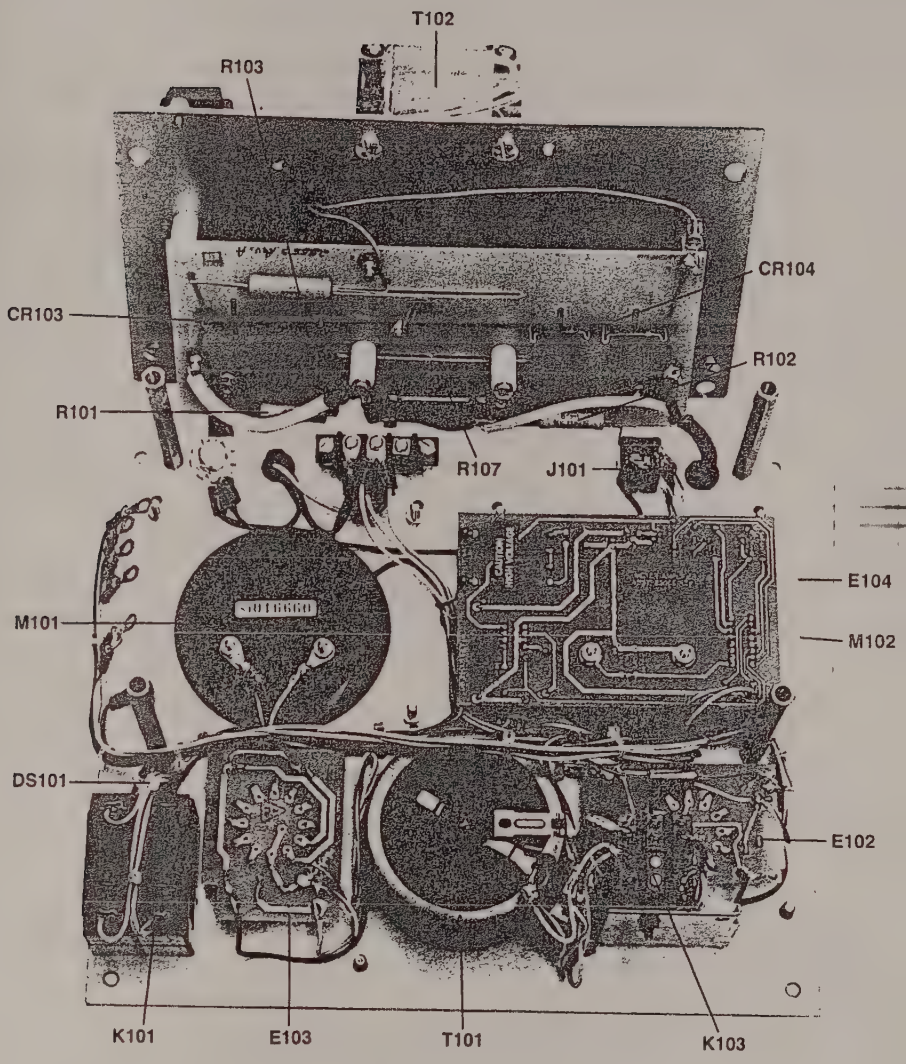


Figure 8: Megohmmeter Test Set Interior.

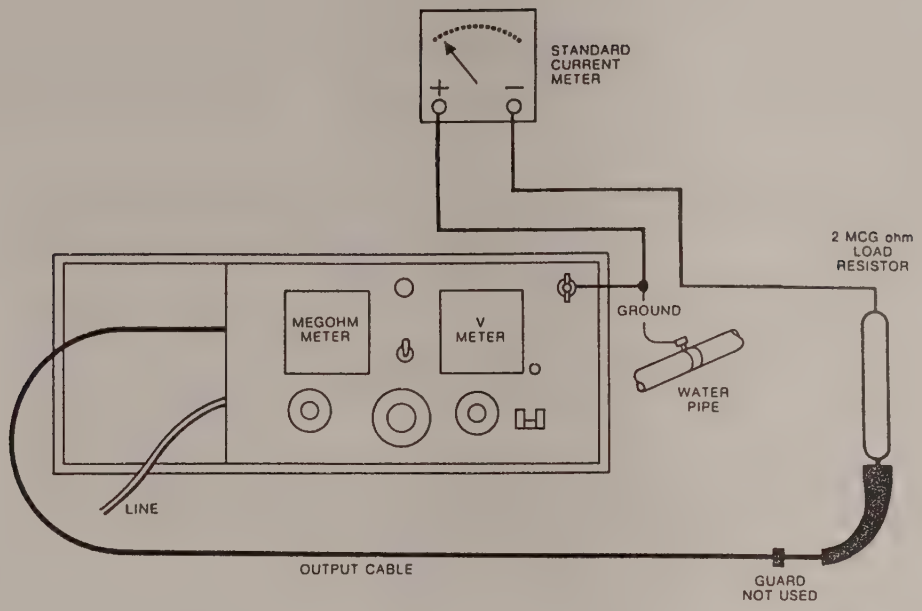


Figure 9: Connections for recalibration of the Megohmmeter.

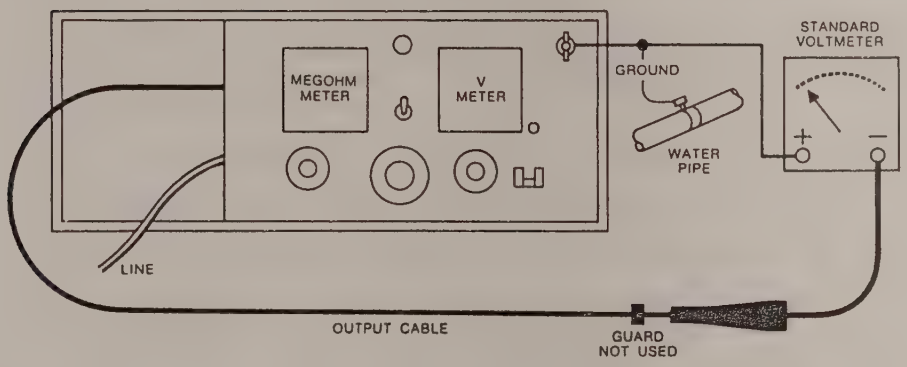


Figure 10: Connections for recalibration of Voltmeter.

SECTION M

PERFORMANCE CHECK

The procedure given below can be used to check equipment performance in the shop after routine maintenance as described in Section K, or after making repairs as indicated as Section L.

After the equipment is set up, the performance check can be completed in about five minutes.

The procedure may be used in the field prior to conducting tests to confirm that the equipment is operating properly and thereby ensure valid test results.

NOTE: Since high voltage will be developed during this test, persons conducting the test must be familiar with the safety precautions normally followed when operating high voltage equipment and must take all necessary measures to avoid shock hazard.

Follow the procedure given below:

1. Set up the equipment as indicated in Section G. Suspend the output lead so that the high voltage clip is clear of all objects by at least two (2) inches.

2. Set the voltmeter range to 5kV and the megohm meter range to X1K.

3. Operate the set according to the procedure given in Section H, raising the voltage to 5kV. Note that the megohmmeter indicates more than 100 megohms. That is, the actual resistance should be above 100,000 megohms.

4. Follow the shutdown procedure given in Section H.

5. Connect the high voltage output to ground.

6. Set the voltmeter range to 2.5kV and the megohmmeter range to X1.

7. Operate the set and very carefully turn up the voltage control. Note that the megohmmeter moves to full deflection.

8. After reaching full scale on the Megohmmeter with the X1 Range in use, advance the voltage control to 35 and note that the main circuit breakers trip out in 20 seconds or less.

SECTION N

PARTS LIST

SYMBOL	DESCRIPTION	JGB PART NO.
-	Complete Case and Lid	25523
-	Case Feet	5599-1
-	Carrying Strap and Bails	6580-2
W100	Input Cable	4127-2
W101	Output Cable	6437
W102	Ground Cable	4702
C104	Capacitor	12019-10
DS101	Power ON light	4499-1
E102	Megohm Range Selector P.C.	4986 *
	Knob Megohm Range	9998-22
K101	Main Breaker	6807-6
K102	Control Relay	9270
M101	Voltmeter	25279
M102	Megohm Meter	25278
T101	Voltage Control Autotransformer	25849
	Knob	4690-1
[1]T2	Transformer Line Adj.	22758-1
[1]T3	Autotransformer	22754-1
R104	Potentiometer	4418-3
R105	Potentiometer	4418-6
E103	Voltmeter Range Selector PC	22521-1
E104	Meter Amplifier Board	25006 *
	Knob Voltmeter Range Switch	9998-8
S102	Meter Damping Switch	12119-3

Chassis Mounted Assemblies

E101	Rectifier/Resistor Assembly	25553 *
T102	High Voltage Transformer	6407
C101	Filter Capacitor	6406
C102	Filter Capacitor	6406

[1] Use on sets supplied with -47 option.

* Can be returned as separate assembly for repair.

SECTION P

WARRANTY AND REPAIRS

Warranty

All products supplied by Biddle Instruments are warranted against all defects in material and workmanship for a period of one year following shipment. Our liability is specifically limited to replacing or repairing, at our option, defective equipment. Equipment returned to the factory for repair will be shipped Prepaid and Insured. The warranty does not include batteries, lamps, or tubes, where the original manufacturer's warranty shall apply. WE MAKE NO OTHER WARRANTY.

The warrranty is void in the event of abuse or failure by the customer to perform specified maintenance as indicated in the manual.

Repairs

Biddle Instruments maintains a complete instrument repair service. Should this instrument ever require repairs we recommend that it be returned to the factory for repairs by our instrument specialists. When returning instruments for repairs, either in or out of warranty, they should be shipped Prepaid and Insured, and marked for the attention of the Instrument Service Manager.

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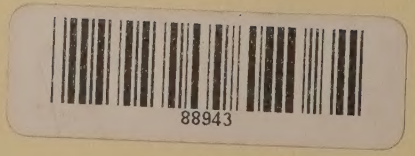
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